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# Stability and Accuracy of Long-Term Memory for Musical Pitch

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**Abstract**—Existing research gives an inconsistent picture of the nature of the cognitive processes underlying memory for musical information. A study was conducted to investigate the stability and accuracy of long-term memory for pitch amongst individuals who have not had musical training. Excerpts from well-known pop songs were used as stimuli. Participants heard one long sequence of excerpts, each of which had been raised or lowered in pitch by one semitone, or left unaltered. After hearing each excerpt, participants were asked to detect whether it was different from the original version of the song they remembered. Participants were significantly worse at detecting whether the pitch of an excerpt had been changed when the altered excerpt was preceded by an unaltered excerpt or vice-versa, than when they heard two consecutive unaltered excerpts. This suggests that pitch memory is subject to interference from previously presented pitch information.

**Index Terms**—Music, Pitch, Memory, Interference

## I. INTRODUCTION

PITCH, tempo, and timbre are perceptual characteristics of sound that allow listeners to distinguish one piece of music from another. The ability of individuals to perceive and evaluate these characteristics, and the processes that allow them to do so, have been investigated as components of general musical processing. Tempo refers to the pace of a piece of music, while timbre describes the unique ‘voice’ or quality of a sound [1]. Pitch describes how high or low a sound is, and is also involved in the interpretation of meaning in speech [1] [2]. The smallest meaningful pitch interval between two notes in Western music is one semitone. Absolute Pitch (AP), the ability to identify the frequency or name of an isolated musical note (e.g., B flat), or to produce a note of a specific frequency on demand, is thought to occur in some individuals who have exceptionally stable and accurate internal pitch representations [3].

The investigation of musical processing as a distinct cognitive faculty is a relatively recent development in psychological research. Studies of working memory for pitch information and emerging research into music-specific neurological deficits provide compelling evidence that music

perception and memory involve cognitive processes that are relatively independent of those related to other auditory stimuli, and that can be influenced by training [2] [4] [5]. Studies suggest that musical training improves the efficiency and accuracy with which pitch information is encoded into, and recalled from, both short and long-term memory. While there is consistent evidence to indicate that musicians are better than non-musicians in most tasks requiring accurate pitch discrimination and memory, researchers disagree about the extent to which these abilities are accurate and stable in untrained individuals. Some research indicates that long-term pitch memory for very well-known music is also stable and accurate among non-musicians [1] [6].

### A. Interference and Working Memory for Pitch Information

Working memory processes related to musical stimuli were a key focus of early music researchers. For example, Wickelgren [7] studied the extent to which subsequently presented tonal information created interference in memory for the pitch of a single musical tone. Participants heard two tones of two, four, or eight second duration each, separated by an interference tone of various pitches and durations. Participants’ accuracy in judging whether or not the first tone was the same as the target tone decreased significantly as the duration of the interference tone increased. Accuracy also increased modestly but steadily as the duration of the first tone increased, which Wickelgren attributed to the strengthening of the memory trace for the pitch of that tone. However, memory accuracy was reduced from the two to the four second interference tone conditions by a greater amount than between the four and eight second interference tone conditions. Wickelgren suggested that this indicated an asymptote effect whereby the strength of the memory trace decays to a constant level after four to eight seconds have elapsed. These findings were some of the first to indicate that storage of pitch information in working memory is subject to interference from other musical stimuli, a conclusion that has been convincingly supported by more recent research. However, Wickelgren made little attempt to discuss and defend working memory processes which may have been responsible for his findings.

### B. The Existence and Role of a ‘Musical Loop’ in Working Memory

Mohr and Pechmann [4] examined the extent to which tonal, verbal, and visual stimuli interfered with the ability of

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musicians and non-musicians to hold pitch information in working memory. Mohr and Pechmann's experimental design was underpinned by Baddeley's model of working memory, which conceptualises working memory as being comprised of three separate but inter-related systems – the visuospatial sketchpad, which processes visual and spatial information, the articulatory loop, which processes verbal and auditory information, and the central executive, which co-ordinates the activity of the other two systems and the attentional resources devoted to different aspects of a task [8]. Baddeley suggests that auditory information must be continually rehearsed to be retained in the working memory store, and Mohr and Pechmann proposed that it is this rehearsal that is affected by interference from other stimuli. They also proposed that musical training may lead to the development of a sub-system in the articulatory loop that deals exclusively with musical stimuli, and hence musicians' processing of tonal and verbal stimuli would be subject to different levels of interference from subsequently presented tonal and verbal information, while non-musicians should experience similar levels of interference for both types of information.

A second aim of Mohr and Pechmann's [4] study was to assess whether the amount of attention devoted to the pitch comparison task affected the accuracy of a listener's memory. Fourteen musicians and 13 untrained listeners heard two tones that were either identical, or a semitone apart, and asked to judge whether they were identical. In the five second interval between the notes participants heard a series of musical tones, single syllable nouns, or silence. In a fourth condition, they saw black and white grids in the interval between tones. In half the conditions, participants were instructed to ignore the stimuli between the two target tones, while in the other half they attended to the intervening stimuli as part of a secondary task. Both groups made significantly more correct judgements in the verbal and tonal attended conditions in which the target tones were identical, than those in which they were non-identical. While the memory of non-musicians for the pitch of the first tone was subject to interference from all types of stimuli tested, their performance was most significantly impaired by other tonal stimuli. Tonal stimuli were also the only kind that created significant interference for musicians' memory for the pitch of the first tone. Mohr and Pechmann suggested that the markedly worse performance by musicians in the tonal condition was due to a form of interference specific to tonal stimuli, whereby the initial tone was overwritten by subsequent tonal information in a process that was automatic and almost uninfluenced by expertise or increased attention.

The results of this study suggest that divided attention also impairs recognition memory among non-musicians, even when the comparison and intervening stimuli are presented in different modalities. Mohr and Pechmann [4] propose that while a tonal loop may exist in the working memories of both groups, untrained listeners must devote more attention in order to encode pitch information into it, a difference that leads to

memory impairments for untrained musicians when they perform a distractor task in between comparing tones. Participants were also significantly more accurate when comparing identical tones than non-identical tones across all conditions. The authors suggest that the comparison tone in the identical pair reactivates the stored representation of the first tone and reduces the 'blurring' introduced by the intervening stimuli. The findings of this study provide support for Mohr and Pechmann's proposition that a tonal loop exists in working memory which is particularly efficient in trained musicians, allowing them to rehearse and retain tonal information relatively independently of other auditory stimuli, and with greater ease than non-musicians. This theory may also account for the superior pitch memory of musicians in comparison to non-musicians that has been observed by other researchers (e.g., [1] [9]).

Palmer and Schendel [5] provide evidence that having to produce tones of a different pitch to an initial tone interferes with a musician's ability to hold the pitch of the first tone in working memory. This is consistent with the findings of Wickelgren [7] and Mohr and Pechmann [4], which indicate that hearing tones of a different pitch immediately after hearing a target tone creates interference in memory for the first tone.

#### *C. Accuracy of Long-Term Pitch Memory in Vocal Production Tasks*

To test the accuracy of pitch memory among non-musicians who presumably lack pitch labeling skills, Levitin [6] had 46 amateur singers sing or hum two different popular songs that they selected from a range of choices as songs they knew well. Their performances were compared with the versions of each song recorded by the original artist. Forty percent of participants were able to sing familiar songs accurately to within one semitone in at least one trial, and 12% were able to do so in both trials. Forty-four percent of participants sang within two semitones of the accurate pitch on both trials. Levitin's definition of accuracy was fairly broad – participants could sing a full semitone sharp or flat and still be classified as correct. This is likely to have led to an overestimation of the untrained singers' pitch accuracy when reproducing familiar songs from memory. The results of this study provide some support for Levitin's proposition that pitch memory is moderately accurate among untrained listeners. However, participants were allowed to begin singing from any point in the song they chose, and only the first three notes each singer produced were compared with the performance of the recording artist. This small sample provides a very limited representation of the overall accuracy of the pitch information stored in each singer's memory. Analysing the pitch of a number of notes from various points throughout the song, or of a greater number of successive notes, would provide a more valid impression of the characteristics of pitch memory. Furthermore, this study is underpinned by the assumption that vocal reproduction accurately reflects the representation of a song held in memory. Pauws [1] found significant variability

in the pitch of successive singing performances of the same song by untrained singers, which suggests that amateur singers are not particularly consistent when performing songs from memory. Therefore, the accuracy estimates of pitch memory gained through studies that rely on analysis of participants' singing may not be valid, and further research is needed that uses data other than sung performance to convey remembered pitch information.

Pauws [1] compared the abilities of 18 trained and amateur singers to accurately reproduce the pitch, tempo, and intervals between notes in songs they knew well. He hypothesised that the song performance of trained singers, who have been taught to discriminate subtle pitch and tempo information in the music they hear and to integrate this into their performance, would improve after hearing the song played aloud, while untrained singers would not improve. He also proposed that singers in both groups should be able to accurately reproduce pitch and tempo information from memory, particularly for familiar songs, and that trained singers should be able to produce more correct intervals than untrained singers. Participants were presented with the titles of two songs by The Beatles that they had nominated as very familiar to themselves, and of two with which they were less familiar. They were asked to choose and sing a passage from each song twice without using the lyrics (i.e., just the melody), and then, after hearing the song played on a CD player, to sing the same passage a third time. These performances were recorded, and the recordings analysed to create transcriptions of the melody produced by each singer. These transcripts were compared with the 'correct' scores corresponding to the passages participants had chosen, as performed by The Beatles. These scores were drawn from published songbooks containing transcriptions of The Beatles music.

All participants sang each song in the uncued condition twice, in order to establish whether they could replicate their performance. While trained singers accurately reproduced the first note approximately 16% of the time in both trials, the pitch production accuracy demonstrated by the untrained singers differed significantly between the first and second times they sang each melody – 8% and 5%, respectively. While these results, like those obtained by Dalla Bella, Giguère and Peretz [9], suggest that trained musicians are significantly more accurate when recalling pitch information than untrained individuals, the accuracy scores for singers in both groups were markedly lower than those obtained by other researchers (e.g., [6] [10]).

In Pauws' [1] study, pitch production accuracy improved significantly for both trained and untrained singers when they sang immediately after hearing the original recording of the song. Trained singers reproduced the pitch of the first note of each melody in 47% of trials, or produced a note that was a single semitone above or below the correct pitch. Untrained singers were accurate in 23% of trials, and sang within one semitone of the correct pitch on 40% of trials. The significant improvement by both groups is at odds with Pauws' hypothesis

that cueing should enhance performance only for trained singers. This finding suggests that both trained and untrained singers are able to discriminate and remember subtle pitch and tempo information, and to evaluate and alter their own performance to better reflect this information. Trained singers were also more accurate at singing intervals than untrained participants. They correctly produced 62% of the intervals across trials in the uncued condition, while untrained participants were accurate 56% of the time. Both groups produced significantly more accurate intervals when singing very familiar songs in the uncued condition than when singing less familiar songs. Pauws suggests this as evidence that, for both musicians and non-musicians, pitch information for well-known songs is more stable and accurate than for less well-known songs. This conclusion is further supported by Levitin's findings that pitch memory for very familiar songs is accurate even amongst individuals with no musical training.

Participants from both groups in Pauws' [1] study were able to sing significantly more correct intervals of less familiar songs in the cued condition than the uncued conditions. Pauws interprets this improvement as indicating that hearing a song played acts as a cue that activates the representation of that song stored in the listener's memory, allowing them to sing it with greater accuracy. This conclusion is also consistent with research conducted by Herbet and Peretz [11], who noted an improvement in participants' singing performance after hearing the song aloud. However, it is also possible that participants were simply reproducing the information they had memorized from the most recent playing of the song that they heard immediately before singing. Unfortunately it is impossible to distinguish whether the most recent memory of the song or a more stable, long-term memory is guiding this singing. No significant difference was found between the pitch production accuracy for the first note of less familiar songs in the cued and uncued conditions for either group of singers. Production of the initial note and of intervals both rely on the singer's internal representation of pitch information, so it seems odd that the presence of a cue should improve reproduction of the latter and not the former. All the trained singers in the study had at least five years of formal music education. As with the study conducted by Palmer and Schendel [5], singers at this level of training are likely to be proficient, but may not have attained genuine expertise. Therefore it is possible that more experienced singers might exhibit different levels of accuracy.

In a study investigating the accuracy of long-term memory for the pitch of well-known melodies, Schellenberg and Trehub [10] played pairs of excerpts from television theme tunes to a group of college students who did not have extensive musical training, and who claimed to be very familiar with each of the tunes presented. While the excerpts in each pair were taken from the same tune, one had been raised or lowered by one or two semitones. The participants were able to identify which excerpt had been altered in 58% of trials in which the alteration was one semitone, and in 70% of trials

in which the excerpt had been altered by two semitones. This experimental design has the same flaw as that used by Pauws [1] – namely, that it is impossible to determine whether participants were comparing the altered song to the relatively recent memory of the correct version played immediately beforehand, or to the representation that had been stored in memory for a much longer period, and which had been developed through repeated exposure. Therefore, it is uncertain whether their results reflected the accuracy of the older or more recent memories of each song.

Schellenberg and Trehub [10] attempted to remove these possible cueing effects in a second experiment, in which participants heard each excerpt in isolation. Participants could judge whether the excerpt had been altered significantly more accurately in the first trial in this condition than in subsequent trials, although they performed significantly above chance in all trials. The authors suggested that this particular finding indicates that the recall of stable, long term memory for songs is subject to interference from similar music stimuli. They proposed that the decline in participants' recall accuracy in later trials suggests that cumulative exposure to altered excerpts starts to interfere with memory for the original pitch level of subsequent songs. However, when participants heard excerpts from unfamiliar melodies paired with identical excerpts that had been raised or lowered in pitch by one or two semitones, they were no better than chance at identifying which excerpts had been altered. This suggests that memory for novel musical information – in this case, pitch – is relatively inaccurate in individuals without musical training. However, research by Levitin [6], Drayna, Manichaikul, de Lange, Sneider and Spector [12], Pauws [1], and Dalla Bella, Giguère and Peretz [9] indicates that while the process by which musical information is encoded into memory may be more efficient in musicians than untrained listeners, untrained listeners are able to accurately recall the pitch characteristics of songs they have heard many times. Further investigation is needed to determine the role song familiarity plays in the accuracy of pitch recall.

#### D. *The Effect of Interference on the Accuracy of Pitch Recall*

There is some evidence to support the applicability of Baddeley's model of working memory to music processing, and the existence of a tonal loop that, with training, can process musical stimuli almost independently of other auditory information. Pitch information appears to be a particularly stable and salient code in both long and short-term memory, in comparison to other musical characteristics such as tempo. However, some studies suggest that the presence of a cue such as a song title or hearing the song played aloud can temporarily strengthen recall of tempo information. There is substantial evidence that suggests that long-term memory for pitch information is moderately stable and accurate among both musicians and non-musicians. However, estimates of pitch memory vary considerably between studies. While many studies indicate that trained musicians outperform untrained individuals in tests of long and short-term pitch memory,

particularly those tasks that involve novel musical information, the discrepancy between the two groups is less pronounced when the task involves recall of well-known songs. This suggests that while non-musicians may need more exposure to musical information in order to memorise it accurately, non-musicians are eventually able to encode and recall pitch information accurately. The inconsistencies between studies indicate that research is needed to further clarify the nature of memory for pitch information, and the extent to which familiarity with a piece of music interacts with musical training to influence the accuracy of pitch recall. The predominance of studies that evaluate pitch memory by analyzing singing performances also suggest a need for additional research that assesses this type of memory in other ways, to avoid the potential confounding effects of mismatches between the pitch information participants remember, and that which they are capable of producing.

The existence of interference has been widely validated by psychological research, and has been shown to affect memory for a range of different types of information. A number of researchers have examined the impact of interference on working memory for musical and non-musical auditory information [4] [5] [7]. This research provides compelling evidence that when an individual is asked to recall a particular piece of auditory information, various types of other auditory information presented close to the time of recall do interfere with their ability to remember the target information accurately. Given the existence of interference in memory for other types of auditory information, it is likely that such interference may also affect memory for music. However, little research exists to support or dispute the existence of interference in long-term memory for music. The present study was designed to test the hypothesis that among listeners who do not have musical training, the pitch of a previously heard excerpt from a well-known pop song will impair an individual's ability to accurately recall the pitch of the next excerpt they hear.

## II. METHOD

### A. *Research Design*

The experiment utilised a repeated measures design. All participants performed in each of the nine conditions. The conditions varied in terms of the pitch of the pairs of song excerpts presented (see Table 1).

TABLE 1  
THE CONDITIONS OF THE EXPERIMENT.

Condition	Excerpt 1	Excerpt 2
1	normal	normal
2	normal	lowered
3	normal	raised
4	lowered	lowered
5	lowered	raised
6	lowered	normal
7	raised	raised
8	raised	normal

*Note:* normal: the excerpt was played with the normal, unaltered pitch; lowered: the pitch of the excerpt was lowered by one semitone; raised: the pitch of the excerpt was raised by one semitone.

### B. Participants

Participants in this study were 20 undergraduate students from Edith Cowan University and 10 individuals from outside the university. The sample was comprised of 22 females and 8 males aged between 18 and 48 years ( $M = 26.97$ ,  $SD = 8.55$ ). Only those individuals who had never had music lessons were invited to participate in the study.

### C. Materials

Songs considered as stimuli in this study were selected from the top 100 best-selling singles charts from the UK, the USA and Australia over the last 20 years, that were classified as pop or soft rock, and that had lyrics as well as music. A shortlist of 130 songs was compiled on the basis that they were likely to be familiar to the potential participants in the experiment. Digital versions of these songs were circulated via email among university students who were acquaintances of the first author. The students were asked to identify those songs on the list they were familiar with. Songs that were recognised by at least five individuals in this survey were selected for inclusion as stimuli in the experiment. Pop songs were chosen as stimuli because usually only one version of a song, performed by one artist or group, is heard multiple times by listeners, and always at the same pitch [6]. Such repeated exposure to the same stimulus increases the likelihood that participants will have formed strong memories for the songs presented in the experiment. CD recordings of these songs were converted to a digital format and copied into the music editing software Audacity version 1.2.6. This software program was used to extract excerpts from the recording of each song, and to raise or lower the pitch of some excerpts by one semitone. The excerpts were played to participants through the computer program Superlab 4.0, over Sony MDR E818 headphones. Participant responses were recorded using an RB-830 response box.

### D. Procedure

In each trial, participants heard a 30 second excerpt of a well known pop song. They then had ten seconds to make a judgement about whether or not the song they heard was different from the original recording of that song, and to press buttons on a response box to indicate a judgement of same or different, or to indicate that they had never heard the song. The next trial began immediately after they had entered a response, or after ten seconds had elapsed. No feedback was provided regarding each response. Each participant performed 100 trials in a single session of approximately 66 minutes. The trials were presented in one of five orders, and six participants heard each presented order. Although there were a minimum of five pairs of songs in each condition in each version of the experiment (e.g., five pairs consisting of one normal excerpt

followed by an excerpt raised by one semitone, for a total of ten excerpts in the normal-raised condition), the different presentation orders meant that there were different numbers of additional pairs in each condition in each of the five presentation orders. This was because the second excerpt of each pair could also be considered as the first excerpt of the subsequent pair. Participants completed between 14 and 28 trials for each experimental condition depending on which presentation order they experienced. Another 10 additional song excerpts were presented at random points in the experimental sequence. The inclusion of these filler trials was intended to prevent participants from guessing the pattern underlying the order in which songs were presented.

## III. RESULTS

The main measure of interest in this experiment was the number of correct responses (%) participants gave for the second excerpt of each pair in each of the conditions. Trials in which participants indicated that they had never heard the song before were excluded from the analysis, as were the data from the filler trials and those trials in which participants entered no response.

Normality screening identified one participant as an outlier. This individual performed significantly better than the other participants in all conditions, and their mean score was more than three standard deviations above the group mean. Data from this participant were excluded from further analysis.

A one-way repeated measures ANOVA was conducted to compare correct responses as a function of condition. There was a significant effect of the pitch of the previous song on participants' ability to accurately detect whether or not the pitch of the second excerpt in a pair had been altered,  $F(8, 224) = 22.155$ ,  $p < .05$ . Tukey's HSD comparisons were conducted to identify the location and size of differences between the means of each condition (see Figure 1). Performance was good in Condition 1 (normal-normal), however performance in all other conditions was poor. This indicates that correctly detecting that the pitch of an excerpt had been altered was difficult (Conditions 2, 3, 4, 5, 7 & 9), but so was correctly detecting that the pitch had not been altered following the presentation of an excerpt where the pitch had been altered (Conditions 6 & 8)

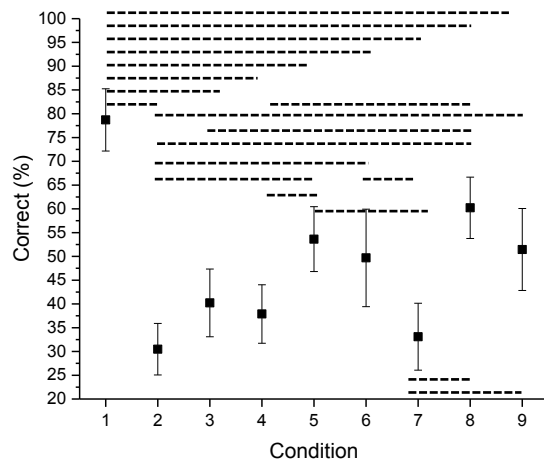


Fig. 1. Percent correct identification of the pitch of a song excerpt as a function of experimental condition. Error bars are 95% confidence intervals. Dashed lines indicate conditions that were significantly different ( $\alpha=.05$ ) according to Tukey's HSD comparisons.

#### IV. DISCUSSION

The results of this study indicate that hearing a familiar song that has had its pitch altered by one semitone impaired the ability of the participants to detect whether or not the pitch of a subsequent song had been altered. Participants were particularly inaccurate at judging the pitch of an excerpt that had been lowered by one semitone when it was preceded by an unaltered excerpt (Condition 2). This suggests that hearing a song at a pitch that matches their stored representation for that song creates significant interference in a listener's ability to accurately recall the pitch of a song they hear shortly afterwards, and to detect that it is a semitone lower than the version they remember. However, participants were not markedly inaccurate at detecting pitch alterations in a raised excerpt when it followed a normal excerpt (Condition 3). This may indicate that listeners have more difficulty detecting subtle pitch variations from their stored representations of music when the variation involves lowering rather than raising the pitch of the remembered song. Participants were also moderately inaccurate at detecting pitch alterations when they heard an excerpt that had been raised one semitone in pitch preceded by another raised excerpt (Condition 7), which suggests that hearing altered pitch information creates some interference in a listener's ability to accurately recall the pitch of a subsequent song when its pitch has been altered in a similar direction, and to detect that this alteration has taken place.

Participants were particularly good at detecting that the pitch of a normal excerpt had not been changed when it was preceded by an excerpt that had been raised by one semitone (Condition 8). This suggests that hearing a song at a higher pitch than the version of that song they have in memory prior to hearing a normal song does not create interference to the same degree as hearing a lowered excerpt prior to a normal song (Condition 6). Participants were moderately accurate at

detecting pitch alterations when raised excerpts were followed by a lowered excerpt (Condition 9) and lowered excerpts were followed by a raised excerpt (Condition 5), which suggests that listeners are slightly more accurate at detecting deviations from the representations of pitch information they have in memory when the size of the pitch alteration separating two consecutively presented songs is two semitones instead of one.

Several participants had never heard a number of the songs presented as stimuli in this experiment, and were therefore unable to make a valid judgement about whether or not the pitch of these songs had been altered. While the exclusion of these trials from the calculation of individual participants' overall accuracy rate in detecting pitch alterations was deemed necessary, it is possible that this may have artificially raised or lowered their overall scores for a condition in which they were unfamiliar with multiple songs. One participant performed unusually well, achieving an accuracy rate of over 70% in each condition. Although this participant was identified as an outlier and therefore had their data excluded from the final analysis, their high accuracy scores suggest that there are some individuals who have extremely accurate and stable pitch memory and pitch discrimination skills, even without having had musical training.

This study provides some evidence that the long-term pitch memory of individuals who have not had musical training is not particularly stable or accurate. It also suggests that, like memory for other auditory stimuli, recall for music is vulnerable to interference from more recently presented stimuli. While various differences between the way musicians and non-musicians process musical information have been extensively researched, few researchers have examined the impact musical training has on interference in long-term memory for music. Studies of short-term memory suggest that musician's memories for musical information are more resistant to interference from non-musical auditory stimuli than those of untrained listeners [4]. However, some research indicates that subsequently presented musical tones can also interfere with musicians' ability to recall the pitch of an initial tone, sometimes to almost the same extent as they do for non-musicians [4] [5]. Further research is necessary to establish whether the interference in long-term pitch memory created by hearing differently pitched songs close to the time of recall of another song, as identified in this study, is evident among musicians as well as untrained individuals.

Many past studies of long-term pitch memory have required participants to sing or listen to a number of familiar songs one after the other in a short space of time (e.g., [1] [3] [6]). The accuracy with which participants are able to perform pitch judgement tasks involving these songs, or to sing them at the correct pitch, is presumed to reflect the accuracy of their memory for pitch information. However, if the interference that researchers [4] [5] [7] have identified in studies of short-term musical memory also affects the encoding and recall of pitch information in long-term memory, then it is possible that past studies that have utilised multiple musical stimuli

presented in quick succession have underestimated the accuracy of long-term pitch memory among both musicians and non-musicians. To determine whether interference does represent a confound in experimental designs of this nature, future research should be conducted to compare the accuracy of participants' pitch memory in singing or listening tasks that involve multiple songs presented close together in time, with their accuracy when there is a long interval separating the presentation of each song.

This study provides some of the first evidence that long-term pitch memory among individuals without musical training is subject to interference from previously presented pitch information. This finding has significant implications for existing research into pitch memory, some of which may have underestimated the accuracy of pitch recall as a result of the interference created when participants were required to recall pitch information for multiple songs in quick succession.

Curve." (Oxford: Oxford University Press, 2005). Professor Speelman is a member of the Psychonomics Society and the Australian Psychology Society.

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# REFERENCES

- [1] Pauws, S. (2003). Effects of song familiarity, singing training, and recent song exposure on the singing of melodies. Retrieved 7 July, 2009, from <http://ismir2003.ismir.net/papers/Pauws.PDF>
- [2] Ayotte, J., Hyde, K. & Peretz, I. (2002). Congenital amusia: a group study of adults afflicted with a music-specific disorder. *Brain*, 125, 238-251.
- [3] Terhardt, E. & Ward, W.D. (1982). Recognition of musical key: Exploratory study. *Journal of the Acoustical Society of America*, 72, 26-33.
- [4] Mohr, G. & Pechmann, T. (1992). Interference in memory for tonal pitch: Implications for a working-memory model. *Memory & Cognition*, 20(3), 314-320.
- [5] Palmer, C. & Schendel, Z.A. (2007). Suppression effects on musical and verbal memory. *Memory & Cognition*, 35(4), 640-650.
- [6] Levitin, D.J. (1994). Absolute memory for musical pitch: Evidence from the production of learned melodies. *Perception & Psychophysics*, 56(4), 414-423.
- [7] Wickelgren, W.A. (1966). Consolidation and retroactive interference in short-term recognition memory for pitch. *Journal of Experimental Psychology*, 72(2), 250-259.
- [8] Baddeley, A. (1986). *Working memory*. Oxford: Oxford University Press.
- [9] Dalla Bella, S., Giguère, J.-F., & Peretz, I. (2007). Singing proficiency in the general population. *Journal of the Acoustical Society of America*, 121(2), 1182-1189.
- [10] Schellenberg, E.G. & Trehub, S.E. (2003). Good pitch memory is widespread. *Psychological Science*, 14(3), 262-266.
- [11] Herbert, S. & Peretz, I. (1997). Recognition of music in long-term memory: Are melodic and temporal patterns equal partners? *Memory & Cognition*, 25(4), 518-533.
- [12] Drayna, D., Manichaikul, A., de Lange, M., Snieder, H. & Spector, T. (2001). Genetic correlates of musical pitch recognition in humans. *Science*, 291, 1969-1972.

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